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Explorations in the Germination of Sedges

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There are 101 species of sedges (Carex spp.) known to occur in Wyoming. They grow on a wide variety of sites: some are found on the driest plains, while others grow in aquatic conditions. They can be found from the lowest to the highest elevations. Sedges as a group produce most of the palatable forage for game and domestic livestock on alpine and subalpine ranges in Wyoming.[3] In spite of their importance, very little is known about the ecology or physiology of the sedges. To manage rangelands wisely, especially at higher elevations, it is necessary to understand some of the basic factors involved in the reproduction and growth of the sedges. This paper reports the results of germination tests of several species of sedges as follows: under greenhouse conditions in petri dishes, from October 1962 to May 1963, with 27 species; a special test of C. raynoldsii, which was eliminated from analysis in the first test because of poor germination; and in the greenhouse in sand cultures, from February 22 to March 28, 1963, with 4 species.

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[3] *Johnson, W. M. 1962. Vegetation of high altitude ranges in Wyoming as related to use by game and domestic sheep. Wyo. Agr. Expt. Sta. Bul. 387, 31 pp.*

Literature

Literature dealing with the germination of sedges is rare. Bliss [4] reports 6.2 percent germination of arctic seed of C.bigelowii and 2.7 percent germination of C. aquatilis in light between moist filter papers. No germination was obtained in the dark. In another test of seed from alpine areas in Wyoming, no germination was obtained in either light or dark for C. aquatilis, C. drummondiana, or C. scopulorum, the only sedges tested. Of 99 species of flowering plants from Greenland tested by Sorensen in 1941,[5] seeds of 62 species germinated. Nearly half of those which did not germinate belonged to the sedge family. Comes[6] tested one lot of seed of C. aquatilis; he obtained no germination when blotters were moistened with distilled water, but 85 percent germination in 10 days when moistened with a 0.2 percent solution of potassium nitrate at 68°-85°F. Lee [7] germinated excised embryos of Carex lurida Wehl, C. stipata Muhl, and C. scoparia Schk. in culture mediums, and improved root and shoot growth

[4] *Bliss, L. C. 1958. Seed germination in arctic and alpine species. Jour. Arctic Inst. of N. Amer. 11: 180-188.*

[5] *Original article by Sorenson not available; quoted from Bliss (see footnote 4).*

[6] *Personal communication with Richard Comes, 1962.*

[7] *Lee, Addison E. 1952. The growth of excised immature sedge embryos in culture. Torrey Bot. Club Bul. 79: 59-62.*

by adding sucrose to the medium. Rostrup[8] found that seeds of Carex paniculata planted in March, April, or May germinated the following spring. If they were planted as late as June, a second winter was needed for good germination.

The scanty literature available indicates that natural germination of Carex may be very low, and that inducing greater germination may be difficult. Sedges do germinate in nature, however, as evidenced by the prompt invasion of some species along road fills and other disturbed areas.

Methods

Germination was tested under greenhouse conditions in petri dishes. Four replications of 25 seeds were used for each species in each treatment:

1. Control: seed placed on germinating paper, moistened as needed with distilled water, and subjected to existing periods of natural light and darkness in a greenhouse.
2. Continuous darkness: same as control, except seeds placed between two sheets of heavy, blue germinating paper to exclude light.
3. 24-hour cold: seed stored in moist cold (refrigerator) at 34°-38°F., otherwise same as control.
4. 7-day cold: same as above except for length of storage period.
5. 30-day cold: same as treatment 3 except for length of storage period.
6. 90-day cold: same as treatment 3 except for length of storage period.
7. Sulfuric acid (H_2SO_4): seed soaked for 5 minutes in 95 percent sulfuric acid before being placed in petri dishes.
8. Potassium nitrate (KNO_3): same as control except moisture source was a 0.2 percent solution of potassium nitrate.
9. Hydrogen peroxide (H_2O_2): same as control except moisture source was a 1.0 percent solution of hydrogen peroxide.
10. Soil leachate: same as control except moisture source was a leachate obtained by soaking alpine soil in distilled water. A perforated 1-gallon can was three-quarters filled with top soil from the alpine zone of the Snowy Range. Distilled water was added and the percolate caught from the bottom of the can.
11. Sand scarification: seed placed in a bottle of coarse sand and shaken on a Burrell wrist-action shaker for 30 minutes before being placed in petri dishes.
12. Scarification plus leachate: a combination of treatments 10 and 11 (assumed to more nearly approach conditions of nature).
13. Leaching: seed washed for 24 hours in running tap water before being placed in petri dishes.

Greenhouse temperatures were controlled at 60°-70°F. at night and 70°-80°F. during the day. Trials were observed for a period of about 60 days.

All seeds used were collected during the summer of 1962 from alpine and subalpine zones in Wyoming. Seed was available for:

1. C. albo-nigra Mack.
2. C. aquatilis Wahl.
3. C. athrostachya Olney
4. C. atrata L.
5. C. chalciolepis Holm.
6. C. ebenea Rydb.
7. C. egglestonii Mack.
8. C. epapillosa Mack.
9. C. hoodii Boott
10. C. illota Bailey
11. C. kelloggii Boott
12. C. lanuginosa Michx.
13. C. limnophila Hermann
14. C. media R. Br.
15. C. microptera Mack.
16. C. nebraskensis Dewey
17. C. nelsonii Mack.
18. C. nova Bailey
19. C. petasata Dewey
20. C. phaeocephala Piper
21. C. physocarpa Presl.
22. C. praegracilis Boott
23. C. pseudoscirpoidea Rydb.
24. C. raynoldsii Dewey
25. C. rostrata Stokes
26. C. scopulorum Holm.
27. C. tolmiei Boott.

[8] *Rostrup, D. 1899-1900. Hvilkin inflydelse har tidspunktit for spiringsforsogets indleding paa spiringen forbob og spirvnens storrelse. Dansk fronkontrol. 1899-1900: 30-32.*

The germination trials began in October 1962 and terminated in May 1963. Not enough seed of all species was available for all treatments. For this reason, four separate studies were made involving different species and different treatments. A randomized complete block design was used for all trials.

Results

Two of the most notable results of these trials were the extreme variability in germination between the species, and the variability in the response of the species to different germination treatments. Some species failed to germinate, while others showed almost complete germination. Nine species either did not germinate at all or germination was so low regardless of the treatments applied that they were not included in the analyses. These were:

C. aquatilis
C. lanuginosa
C. media
C. physocarpa
C. praegracilis
C. pseudoscirpoidea
C. raynoldsii
C. rostrata
C. scopulorum

Treatment Effects

Some of the treatments proved to be ineffective, and in some cases actually reduced germination when compared with the distilled water control. Seed placed between heavy, blue germination paper (complete darkness) either failed to germinate at all or germination was drastically reduced. Seed stored in refrigerators for 90 days germinated less than the control, in most cases, and always less than seed similarly stored for shorter periods of time. The sulfuric acid and hydrogen peroxide treatments prevented or drastically reduced germination. These four treatments were later abandoned and results were not included in the analyses.

None of the eight treatments tested statistically were consistently successful in increasing germination. Some had both positive and negative effects, depending upon the species being tested. One treatment (sand scarification) had no effect on germination of any of the three species so treated (table 1).

Table 1.--A summary of treatment effects in relation to distilled water control on the germination of Carex seed

Treatment	Species tested	Germination--				No effect	
		Increased		Reduced			
	No.	No.	Pct.	No.	Pct.	No.	Pct.
24-hour cold	16	5	31	3	19	8	50
7-day cold	18	5	28	1	6	12	66
30-day cold	11	1	10	5	45	5	45
Potassium nitrate	13	3	23	2	15	8	62
Soil leachate	13	2	15	0	0	11	85
Sand scarification	3	0	00	0	0	3	100
Scarification plus leachate	3	2	67	0	0	1	33
Tap water leaching	16	1	6	2	13	13	81

The combination treatment of sand scarification with the soil leachate as a moisture source significantly increased the germination on two out of three species tested, however, but the germination of one of these species was increased a similar amount by the soil leachate treatment alone (table 2).

The cold treatments gave variable results (table 2). In comparison with the control, the 7-day cold treatment stimulated germination of 5 species, had 1 negative effect, and did not change the germination of 12 species. The 24-hour cold treatment stimulated germination of 5 species, retarded 3 species, and had no effect on 8 species. In contrast, the 30-day cold period produced only 1 positive effect, had a negative effect on 5 species, and had no effect on 5 other species. Reasons for this variability are not clear, but it would appear that long periods of cold (the 30-day period in the analysis and the 90-day period not analyzed because of its definite negative effect on germination) are not needed for germination of the sedges used in this study.

The use of potassium nitrate as a source of moisture in germination trials produced results similar to the shorter cold treatments: there were 3 positive effects, 2 negative effects, and 8 species were not affected.

The soil leachate treatment increased germination of 2 species of sedge. The leachate was not analyzed, however, so the causative factor or factors are unknown.

Table 2. --Average germination of 25 seeds of each Carex species as related to treatment

Species and test[1]	Treatments							
	Control	24-hour cold	7-day cold	30-day cold	Potassium nitrate	Soil leachate	Sand scarification	Tap water leaching
	Number							
TEST NO. 1:								
C. egglestonii	22.3	22.8	21.5	23.3	11.5	21.5	21.8	22.5
C. atrata	2.0	1.5	2.8	3.5	4.3	5.0	7.8	.5
C. ebenea	13.3	21.0	19.8	24.0	5.3	21.8	22.3	24.5
TEST NO. 2:								
C. nebraskensis	6.5	6.0	9.0	1.3	5.5	4.3		3.3
C. microptera	18.5	18.0	17.3	14.5	17.3	20.8		19.3
C. phaeocephala	16.3	21.5	20.8	16.5	20.5	19.0		18.8
C. chalciolepis	4.0	3.5	7.8	.8	6.5	5.0		2.8
C. epapillosa	5.0	6.8	5.5	0.0	5.5	6.0		4.8
C. hoodii	4.8	1.3	4.8	0.0	5.3	2.5		3.5
C. limnophila	20.8	25.0	22.0	0.0	21.5	23.3		22.3
C. nova	.5	0.0	0.0	.3	7.5	.8		.5
TEST NO. 3:								
C. illota	17.8	11.5	0.0					0.0
C. tolmiei	3.0	6.5	4.0					.3
C. kelloggii	.8	.8	1.8					0.0
C. petasata	1.8	5.3	4.0					.5
C. albo-nigra	2.0	0.0	.5					.5
TEST NO. 4:								
C. nelsonii	4.8		12.5		15.5	17.3		
C. athrostachya	.5		2.5		.3	.3		

[1] Least significant difference at .05 for each test: No. 1 = 5.6; No. 2 = 3.4; No. 3 = 2.0 No. 4 = 5.4.
[2] Underline indicates the species means that differed significantly from the control.

Leaching seed with running tap water was not an effective germination treatment.

Species Germination

Of the 27 species of sedge tested, only 5 can be considered to germinate well, either naturally or by one of the treatments tested (table 3). These are C. ebenea, C. egglestonii, C. limnophila, C. microptera and C. phaeocephala. All germinated between 80 and 100 percent. Both C. ebenea and C. egglestonii appear to germinate readily under almost any conditions. Three-year-old seed of these species has germinated as well as new seed. Seed collected from plants grown in the greenhouse, harvested at maturity, and tested immediately have consistently germinated between 90 and 100 percent. Two other species, C. illota and C. nelsonii, germinated fairly well, but for all others germination was less than 40 percent.

Special Tests of C. raynoldsii

Out of the group of nine species which were eliminated from the analysis because of very

Table 3. --Maximum germination of Carex seeds and treatment responsible

Species	Germination--	
	Percent	Best treatment[1]
C. aquatilis	0	--
C. albo-nigra	8	Control
C. athrostachya	10	7-day cold
C. atrata	31	Scarification plus leachate
C. chalciolepis	31	7-day cold
C. ebenea	98	Tap water leaching
C. egglestonii	93	30-day cold
C. epapillosa	27	24-hour cold
C. hoodii	21	Potassium nitrate
C. illota	71	Control
C. kelloggii	7	7-day cold
C. lanuginosa	0	--
C. limnophila	100	24-hour cold
C. media	5	24-hour cold
C. microptera	83	Soil leachate
C. nebraskensis	36	7-day cold
C. nelsonii	69	Soil leachate
C. nova	30	Potassium nitrate
C. petasata	21	24-hour cold
C. phaeocephala	86	24-hour cold
C. physocarpa	1	7-day cold
C. praegracilis	0	--
C. pseudoscirpoidea	0	--
C. raynoldsii	3	Cutting seed coat
C. rostrata	0	--
C. scopulorum	2	Control
C. tolmiei	26	24-hour cold

[1] Based on mean germination without regard to significance between treatments (see table 2).

poor germination, C. raynoldsii was selected for special supplementary testing. The same general conditions were involved, but the treatments applied to the seed were:

1. Seed soaked in 95 percent solution of sulfuric acid for 30 minutes.
2. Seed soaked in 95 percent solution of sulfuric acid for 45 minutes.
3. Seed coat cut with razor blade.
4. Seed scarified with sand for 3-1/2 hours.

All of these treatments were designed to weaken the rather hard seed coat of this species. The 30-minute soaking in sulfuric acid dissolved the perigynia but left the seed coat hard. The 45-minute soaking softened the seed coat on most seeds but some were still firm. The 3-1/2-hour scarification appeared to do little except wear away the perigynia. Cutting the seed coat did reveal that the embryo appeared to be alive and should be viable, but no viability tests were made.

No germination occurred in any treatment except where the seed coat was cut. In 45 days, 3 percent of the seed germinated. This indicates that future treatments should be based on destruction of the seed coat.

Rate of Germination

The rate of germination of sedge seed was as variable between species as was total germination. For example, seeds of C. microptera in the control treatment germinated very rapidly (fig. 1). Germination started on the 12th day and was finished by the 23rd day of the test. C. ebenea, on the other hand, began germinating on the 9th day and did not stop until the 31st day. C. egglestonii began rapid germination similar to C. microptera (but earlier, on the 9th day), slowed down during the middle of the test, then germinated very rapidly again between the 24th and 31st day. There was no further germination. C. epapillosa, at the low extreme, started germination late and continued to germinate very slowly until it stopped. Germination rates of other species were within the extremes illustrated.

Some treatments appeared to stimulate the rate of germination greatly, but again this varied between species. In some cases the treatments produced immediate and rapid germination, as was the case with the 30-day cold storage treatment in C.egglestonii (fig. 2).

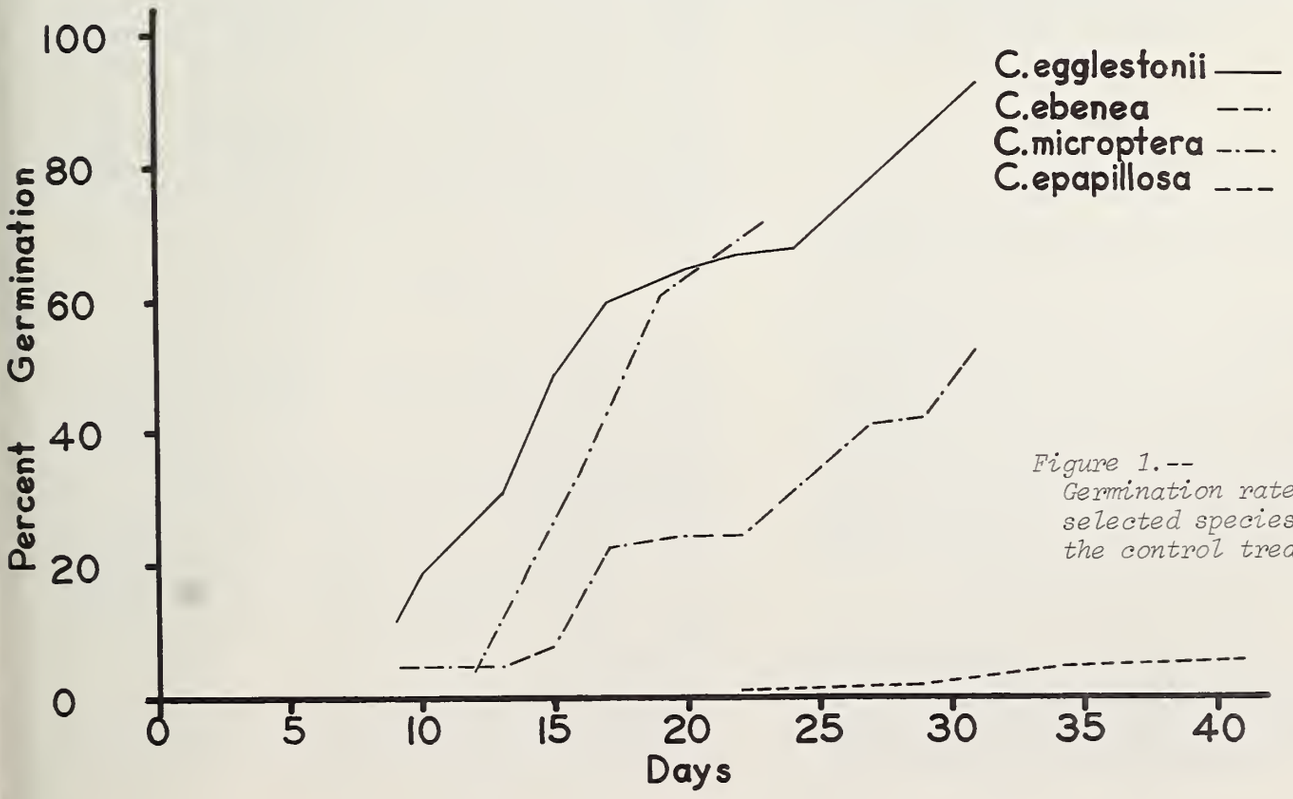

Figure 1.--
Germination rates of seed of selected species of Carex in the control treatment.

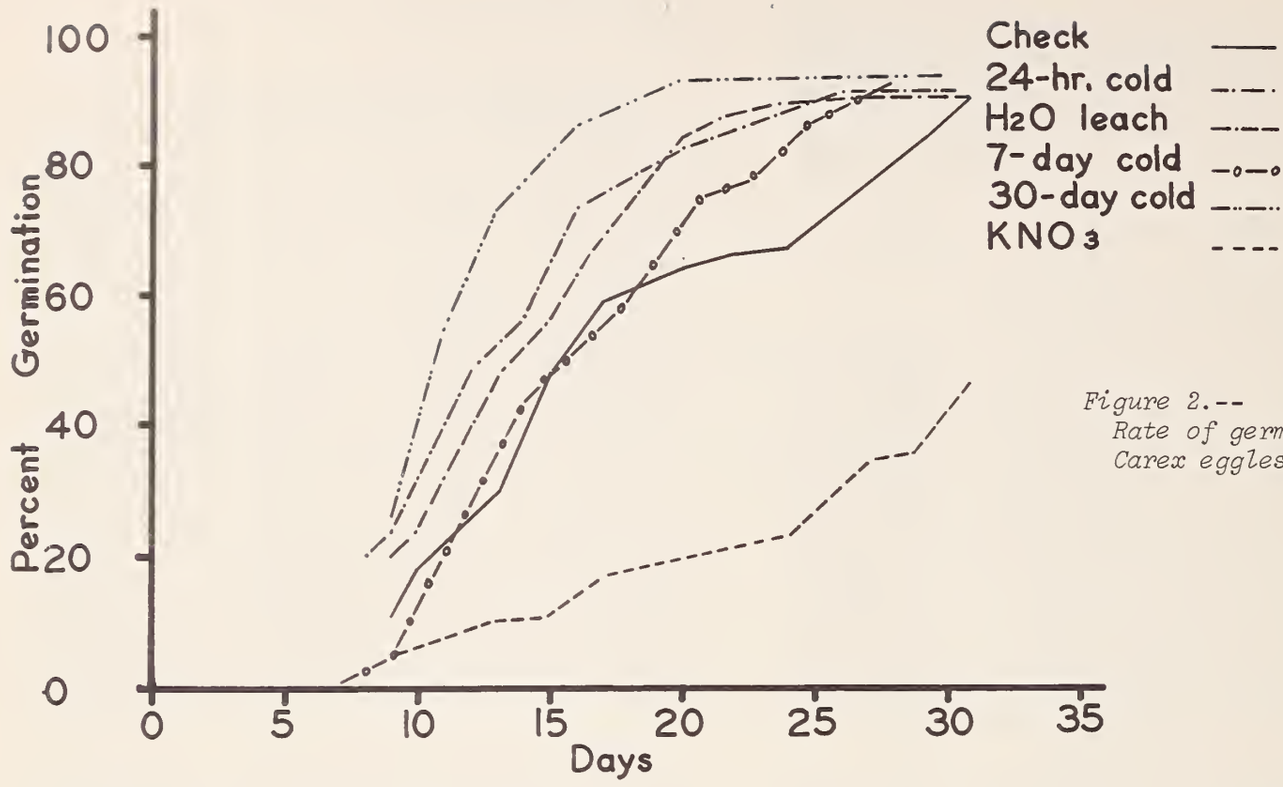

Figure 2.--
Rate of germination for Carex egglestonii.

With this treatment, germination was very rapid between the 9th and 20th days, and was complete at a much higher level than the control at that time. For this species, the tap-water leaching and 24-hour cold treatments had a similar effect. Although none of these treatments increased final germination of this species, they did affect the rate of germination.

Germination in Sand Culture

In still another germination trial, conducted February 22 to March 28, 1963, seeds of four sedge species were planted in sand (with the exception of the water-culture treatment) in waxed paper containers with perforated bottoms. The containers were placed in a tray to which tap water was supplied to maintain soil moisture. During this eight-treatment experiment (table 4), temperature in the greenhouse ranged from 70° to 80° F.; relative humidity and photoperiod were not controlled.

After germination began, containers were observed daily for a 25-day period. A seed was considered germinated when a shoot appeared above the surface of the sand. Except on cloudy days, the blocks of treatments were shaded with paper to reduce evaporation. The paper was elevated so light was not excluded.

First emergence was observed 10 days after planting. The number of plants germinating per day varied from 1 the first day of germination to 55 on the 16th day. C. ebenea and C. egglestonii germinated well, but less than in the previous experiment with petri dishes; C. hoodii and C. nova did not germinate or respond appreciably to any treatment (table 4).

Discussion and Summary

The problem of breaking dormancy in sedge seed is not simple. Each of the species studied seems to be an entity in itself. No single treatment can be listed as effective for all species. Nor can it be said that all species will germinate well or poorly. The study has indicated, however, that some treatments seem to be more generally effective than others. Some of the conclusions that might be drawn from the study are:

1. Light seems to be necessary for good germination. This is evidenced by the very

Table 4.--Percent germination of four species under eight treatments in a sand culture, and comparison of response of C. ebbenea and C. egglestonii[1]

Treatment	Percent germination of--				Comparison of response of C. ebenea and C. egglestonii[1]
	C. ebenea	C. egglestonii	C. hoodii	C. nova	
Control: water only	25	23	0	1	No difference between species, but much lower than in the petri dish experiment
Wetting agents (chemical solutions in place of water for 10 days, then distilled water used):[2]					
Potassium nitrate (0.2% solution)	60	29	1	1	Appreciable increase in germination of C. ebenea but no effect on C. egglestonii
Hydrogen peroxide (1.0% solution)	43	62	1	0	Appreciable increase in germination of both species; in direct contrast to results in the petri dish experiment
Seed subjected to cold period (0°F.) prior to planting:					
24 hours	25	16	0	6	No effect on C. ebenea; decreased germination of C. egglestonii
7 days	31	12	0	0	Slight increase in germination of C. ebenea; decrease in C. egglestonii
Seed soaked in chemical solution for 1 hour prior to planting:					
Potassium nitrate (0.2% solution)	54	11	2	0	Germination doubled for C. ebenea; reduced by approximately 50 percent for C. egglestonii
Hydrogen peroxide (1.0% solution)	24	12	1	1	Germination not affected for C. ebenea; reduced 50 percent for C. egglestonii
Water culture (seed placed on blotter within container, no cover; this treatment most similar to petri dish experiment)	77	89	0	4	Germination increased for both species; reasonably comparable to results in petri dishes
Species mean	42.37	31.75	.62	1.62	

[1] C. hoodii and C. nova not compared; neither species germinated nor responded appreciably to any treatment.
[2] Containers placed in impermeable saucers to prevent chemicals contaminating the tap water in the tray.

low germination of seed placed between layers of heavy, blue germination paper, which can be considered complete absence of light. Also, the germination of seed covered by one-fourth inch of sand was much lower than that of seed of the same species in petri dishes exposed to diurnal light fluctuation. Subsequent studies of growth of C. ebenea and C. egglestonii in soil media have shown lower germination rates than were obtained in the petri dishes. Bliss [4] also observed the importance of light in germination of sedge seeds.

2. Chemical treatments to break dormancy gave highly variable and, in some instances, conflicting results. Sulfuric acid treatments cannot be recommended. Thin-walled achenes so treated were very rapidly co sumed in many cases. For thick, har walled achenes such as C. raynoldsii, t treatment was not effective.

3. Hydrogen peroxide as a moisture sou decreased germination in petri dishes, b did appear to stimulate germination in sand cultures. Reasons for this are not obvious. As a scarifying agent (se d soaked for 1 hour before planting), hydrogen peroxide had no stimulating effect on germination.

4. Germination of seeds treated with potassium nitrate as a moisture source was highly variable, depending upon species. Exceptionally good results were obtained on some species in the petri dish experi-

ment. C. ebenea responded well in both the petri dish and sand culture studies; C. egglestonii did not respond in either study, and germination was actually inhibited in the petri dishes.

5. Surprisingly, the soil leachate appeared to stimulate germination in two cases. Just what factor from the soil is responsible for this stimulus is not known. It does indicate that sedge germination in natural habitats could be expected, and that nature provides her own stimuli.

6. Mechanical seedcoat scarification with sand did not increase germination, but the combination of sand scarification plus soil leachate as a moisture source was effective. This again indicates that natural conditions of the habitat provide some stimulation.

7. Cold treatments to break dormancy have variable effects on germination. Long periods (90 days) of cold storage have little effect on germination, and at least for some species may actually inhibit germination. Cold storage for intermediate or short periods does seem to be beneficial in most instances. The 7-day cold storage was especially beneficial.

The results of these preliminary studies indicate that the germination of sedge seed is not so difficult as earlier studies suggest, but it is highly variable. Although this study has provided some useful guidelines for future investigations of sedge species, additional methods or combinations of methods need to be tested. Among the most promising for future work would be the further testing of light and cold-storage techniques.